



New species, new locality records and descriptions of calling songs of Phaneropterinae from Sabah

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Abstract

Based on recent sampling of orthopterans in Maliau Basin and Meligan (including near Long Pasia and Sinipung Hill), Sabah, Borneo, we present here notes on some of the katydids from the subfamily Phaneropterinae. Two new species were discovered and are described: *Tapiena dimidia* **sp. nov.** from Maliau Basin and *Tapiena muna* **sp. nov.** from Sinipung Hill near Long Pasia and Meligan. New locality records for *Elbenia* (*Elbenia*) *paradigitata* Gorochov, 2023, *Stictophaula multa* Gorochov & Voltshenkova, 2009, *Holochlora falcata* Tan, Liu & Ingrisch, 2024 and possibly *Psyrana* (*Psyrana*) *nr. imitativa* Gorochov, 2024. Calling songs of four species of Phaneropterinae are described for the first time: *Elbenia* (*Elbenia*) *paradigitata* Gorochov, 2023, *Elbenia* (*Elbenia*) *?tenera* Brunner von Wattenwyl, 1878, *Rectimarginalis ensis* (Haan, 1843) and *Tapiena ?incisa* Karny, 1923.

Key words: Bioacoustics, Borneo, *Tapiena*, taxonomy

Introduction

Sabah is a state of Malaysia in Borneo that is known for its high biodiversity, including for orthopteroid insects (e.g., Tan *et al.*, 2019; Cigliano *et al.*, 2024). Owing to the vast area and incomplete sampling, many species of katydids of the subfamily Phaneropterinae are still awaiting discovery in Sabah. Lately, numerous new species of Phaneropterinae have been described from this state, including a new species of *Calopsyra* Brunner von Wattenwyl, 1891 (Gorochov, 2023a), five species of *Elbenia* Stål, 1876 (Gorochov, 2023b), five species or subspecies of the tribe Mirolliini Brunner von Wattenwyl, 1878 (Gorochov, 2023c). Even more recently, Gorochov (2024) described five new species of *Psyrana* from different parts of Sabah, including Tawau Hills and Crocker Range. Tan *et al.* (2024a) also described four new species of *Holochlora* Stål, 1873, one new species of *Deflorita* Bolívar, 1906 and one new genus and species—*Pulchrapsyra cyanea* Tan, Liu & Ingrisch, 2024—all from a single site in Mount Trus Madi.

Orthopteran collection was recently conducted in poorly sampled areas of Sabah, specifically in Maliau Basin and around Meligan. There, we found species new to science and new locality records for previously-described species. Here, we describe two new species of katydids from the genus *Tapiena* Bolívar, 1906: *Tapiena dimidia* **sp. nov.** and *Tapiena muna* **sp. nov.** We also document new locality records of *Elbenia* (*Elbenia*) *paradigitata* Gorochov, 2023, *Stictophaula multa* Gorochov & Voltshenkova, 2009, *Holochlora falcata* Tan, Liu & Ingrisch, 2024 and possibly *Psyrana* (*Psyrana*) *nr. imitativa* Gorochov, 2024 in Meligan and Maliau Basin. We also recorded

and describe the calling songs of four species of Phaneropterinae for the first time: *Elbenia (Elbenia) paradigitata* Gorochoy, 2023, *Elbenia (Elbenia) ?tenera* Brunner von Wattenwyl, 1878, *Rectimarginalis ensis* (Haan, 1843) and *Tapiena ?incisa* Karny, 1923.

Material and methods

Between 10 and 25 November 2024, opportunistic collection and light-trapping (Fig. 1) were conducted at Maliau Basin Conservation Area and around Meligan (including near Long Pasia and Sinipung Hill) in Sabah State (East Malaysia), Borneo. The permissions for collecting and exporting material were granted by the Sabah Biodiversity Centre (JKM/MBS.1000-2/2 JLD.1 and JK M/MBS.1000-2/3 JLD.5 (106)). The permissions for research in Maliau Basin Conservation Area was also supported by the Maliau Basin Management Committee under the Yayasan Sabah (YS/MBMC(RA)/2024/3). The fieldwork was also supported by the National Geographic Grant (NGS-73188R-20). Whenever possible, live specimens were photographed using a Canon EOS 500D digital SLR camera with a compact-macro lens EF 100 mm f/2.8 Macro USM, and Canon Macro Twin Lite MT-24EX was used for lighting and flash.



FIGURE 1. Light trap at Meligan. Photograph by Xavier Desmier.

Sound recording of the male calling songs was done using a Wildlife Acoustics Song Meter (SM) Mini acoustic recorder programmed to record continuously with a sampling frequency of 96 kilo-samples per second and channel gain of 18 dB (16 bit). This was done in captivity. The katydid was kept isolated in a small insect cage with nylon cover and the microphone was placed at most 30 cm away beside the cage with the microphone pointing horizontally towards the cage.

The specimens were preserved in absolute analytical-grade ethanol and later pinned and dry-preserved. Typically, a single leg (not standardised) from each specimen was kept in absolute analytical-grade ethanol for future molecular work.

The pinned specimens were imaged using a Canon EOS 6D digital SLR camera attached to a Visionary Digital Passport system. For habitus, a compact-macro lens EF 50 mm at f/2.5 was used; for close-up images of morphological features, a macro photo lens MP-E 65 mm f/2.8 USM (1–5×) (sometimes with Tamron SP AF Tele-Converter 14OF-CA 1.4×) was used. Image stacking was done using Zerene Stacker version 1.04. Image editing was accomplished using Adobe Photoshop 2025 (Adobe Systems Incorporated, San Jose, CA, USA).

Measurements of dry, pinned specimen were made from images using ImageJ 1.54g (Wayne Rasband, Research Services Branch, National Institute of Mental Health, Bethesda, MD, USA). For the measurements, the following abbreviations are used: BL = body length; BWL = body with wing length; PL = pronotum length; PW = pronotum width (maximum); TL = tegmen length; TW = tegmen width (maximum); HWT = hind wing tail; HFL = hind (posterior) femur length; HFW = hind (posterior) femur width (maximum); HTL = hind (posterior) tibia length.

Acoustic analysis and song terminology generally follow Tan *et al.* (2024b). Parameters of the temporal domain (e.g., durations and intervals) were measured manually using Raven Lite 2.0.0. The peak frequency was obtained using the 'spectro_analysis' function from the R package warbleR version 1.1.27 (Araya-Salas & Smith-Vidaurre, 2017) in the R software version 4.4.1.

The specimens were eventually deposited in:

FRC Forest Research Centre (Sepilok), Sabah Forestry Department, East Malaysia
MNHN Muséum national d'Histoire naturelle, Paris, France
ZRC Zoological Reference Collection, Lee Kong Chian Natural History Museum, Singapore

Taxonomic parts

Subfamily Phaneropterinae Burmeister, 1838

Elbenia (Elbenia) paradigitata Gorochov, 2023

(Figs 2A, 3, 4)

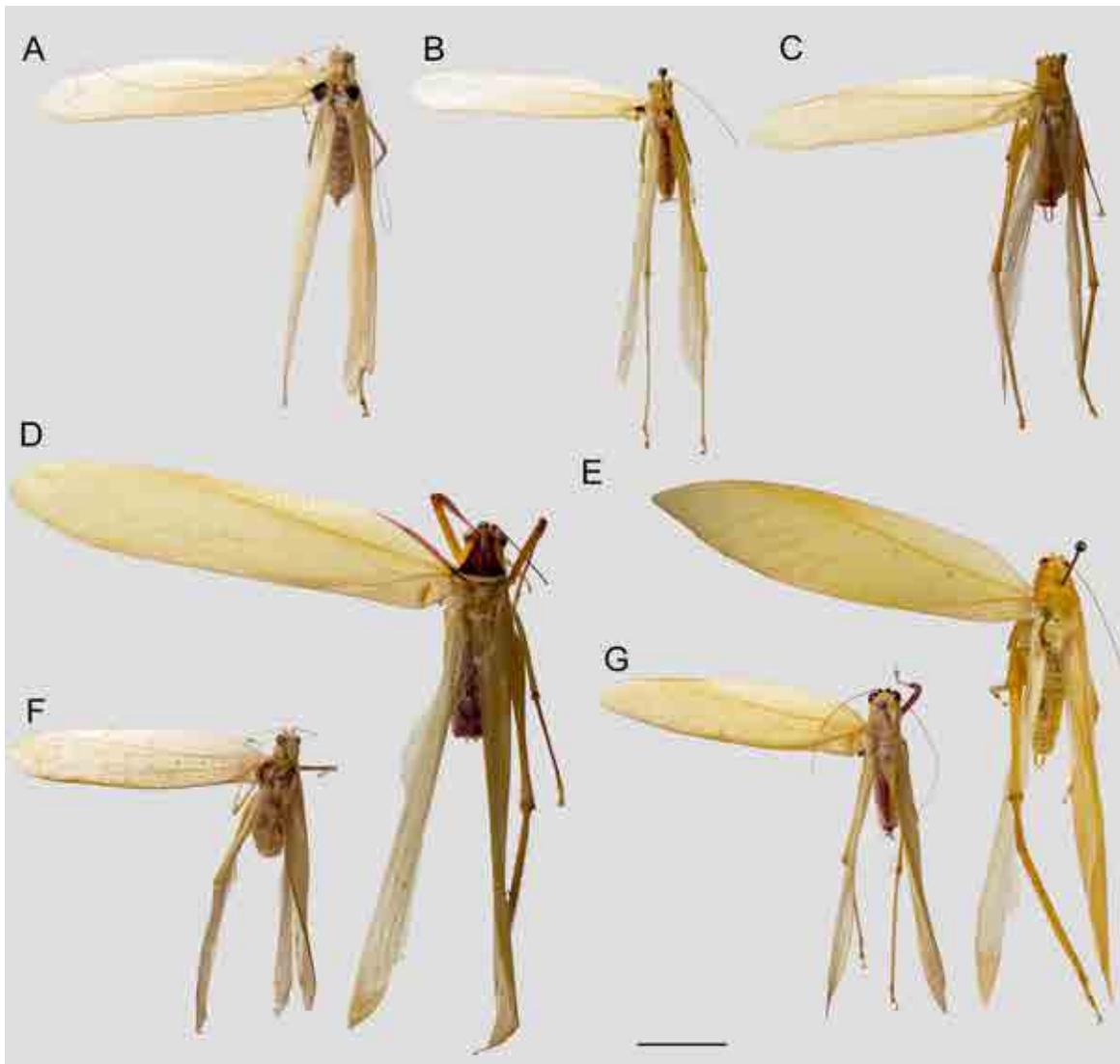


FIGURE 2. Habitus of Phaneropterinae in dorsal view: *Elbenia (Elbenia) paradigitata* Gorochov, 2023 (A), *Elbenia (Elbenia) tenera* Brunner von Wattenwyl, 1878 (B), *Holochlora falcata* Tan, Liu & Ingrisch, 2024 (C), *Psyrana (Psyrana) nr. imitativa* Gorochov, 2024 (D), *Rectimarginalis ensis* (Haan, 1843) (E), *Stictophaula multa* Gorochov & Voltshenkova, 2009 (F), *Tapiena incisa* Karny, 1923 (G). Scale bar: 10 mm.

New material examined. EAST MALAYSIA; Sabah State • 1♂; Sinipung Hill, near Long Pasia and Meligan; N4.43564 E115.72317, 1298.0±9.2 m.a.s.l.; 20 November 2024, 16h30; near leaf litter; coll. M.K. Tan; SBH.24.165 (FRC) • 1♂; Sinipung Hill, near Long Pasia and Meligan; N4.44538 E115.71494, 1556.0±10.1 m.a.s.l.; 21 November 2024, 23h50; attracted to light trap; coll. M.K. Tan; SBH.24.218 (ZRC).

Remarks. Our specimens most resemble *Elbenia (Elbenia) paradigitata* Gorochov, 2023 from Mount Trus Madi (see Gorochov, 2023b). The black patch of the stridulatory area is very similar: its left tegmen having irregularly transverse black patch covering vein 1A but not reaching the mirror (Fig. 3A). The stridulatory file on the left tegmen also has a similar shape and similar number of teeth (circa 70) (Fig. 3C). The shape of the posterior lobe of the male tenth abdominal tergite is similarly slender and narrowly spaced apart; although these lobes can be flexible and appear wider than in its natural shape (Figs 3D–F). Their cerci are similar in their arcuate, long and slender shape, with its apical part directed medially and having an apex tooth-like (Figs 3E–H). The subgenital plate is stout, not necessarily surpassing the apices of the tenth abdominal tergite lobes; its apex with a groove at the base very narrow before widening at its apical end (Figs 3E, 3F, 3H).

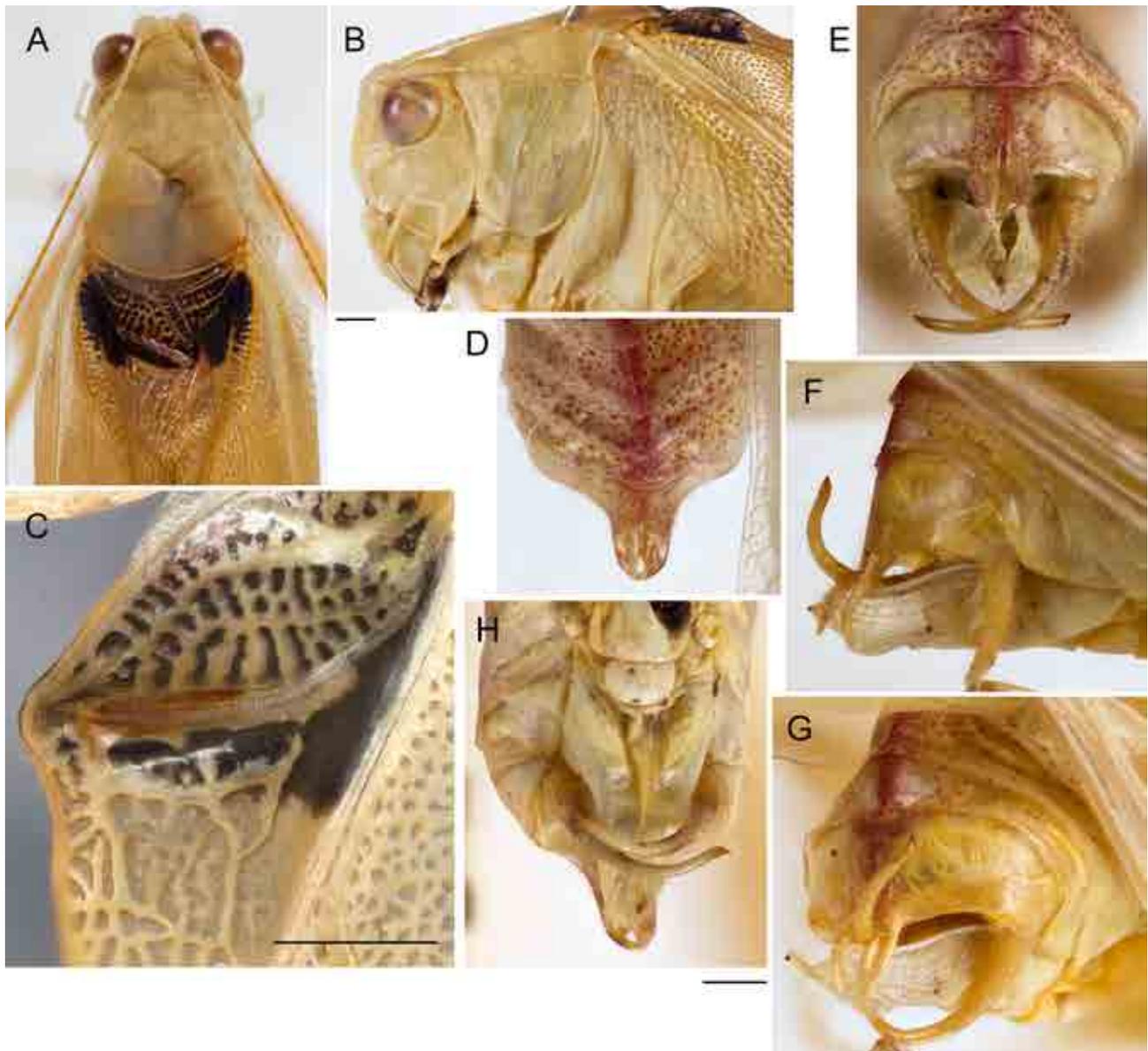


FIGURE 3. *Elbenia (Elbenia) paradigitata* Gorochov, 2023: head, pronotum and anterior parts of tegmina in dorsal (A) and lateral (B) views; stridulatory area of the left tegmen in ventral view (C); abdominal apex in dorsal (D), posterior (E), lateral (F), postero-lateral (G) and ventral (H) views. Scale bars: 1 mm.

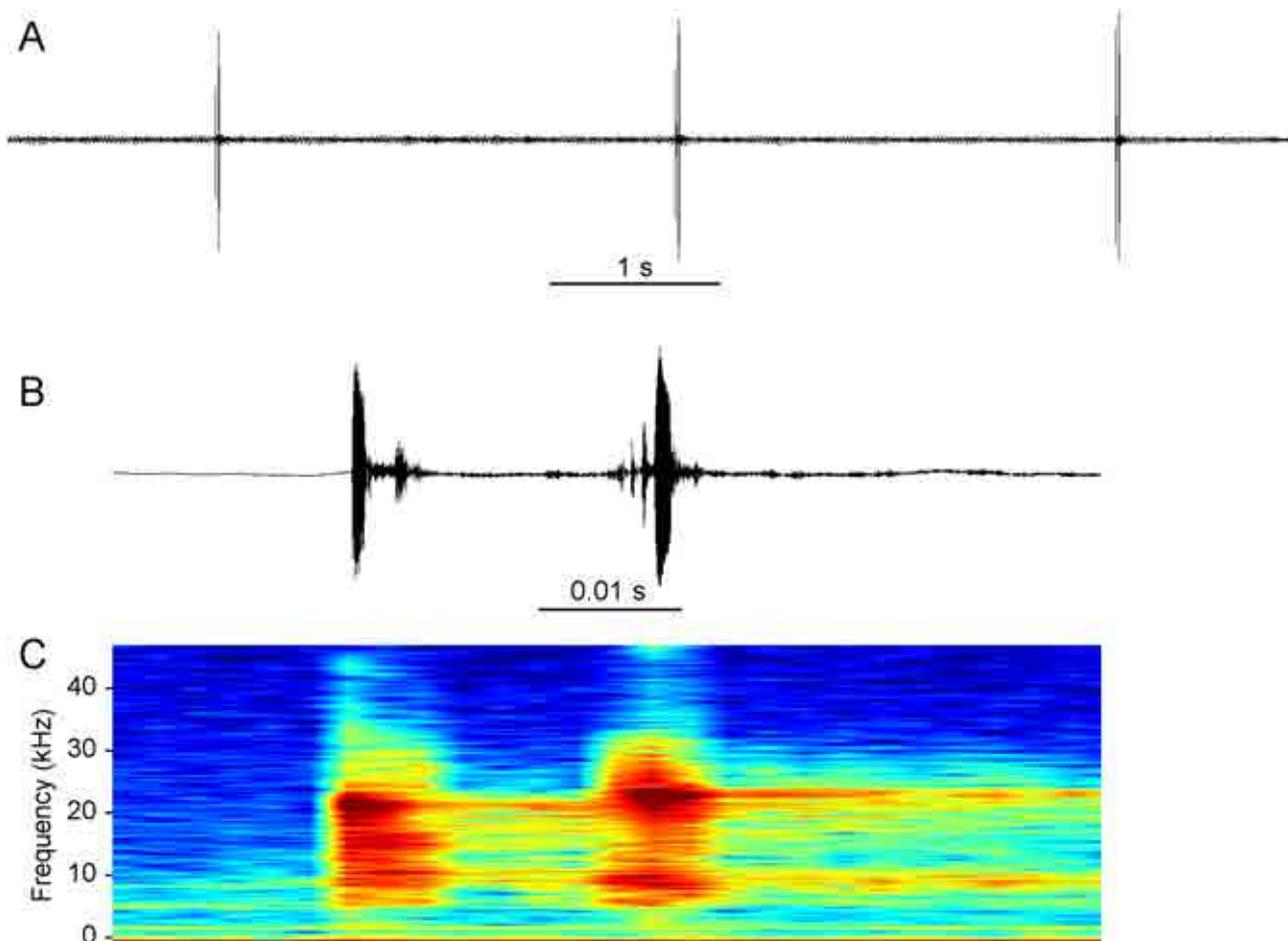


FIGURE 4. *Elbenia (Elbenia) paradigitata* Gorochov, 2023 male calling song: oscillograms showing three echemes (A) and one echeme with two syllables (B); spectrogram showing the same echeme (C).

Type locality. EAST MALAYSIA: Sabah: Mount Trus Madi.

Distribution. Borneo: Sabah State: Mount Trus Madi, Sinipung Hill [new locality record].

Natural history. Compared to the more commonly sighted species *Elbenia (Elbenia) tenera* Brunner von Wattenwyl, 1878, this species was found deep inside the forest, rather than along forest edge or roads.

Calling song (Fig. 4). The calling song is an isolated echeme made up of two syllables. The average echeme duration is 25.0 ± 1.1 ms (22.8–27.2 ms). The first syllable consists of two pulses and has an average duration of 4.6 ± 1.0 ms (3.0–6.7 ms). The first pulse is of a higher energy than the second one and of a slightly longer duration (1.3 ± 0.3 vs. 1.1 ± 0.3 ms). The second syllable consists of three short pulses (duration = 0.3–1.0 ms) followed by a longer pulse (duration = 1.3–2.1 ms). The initial three pulses are of distinctly lower energy than the last pulse; consecutive pulses are of higher energy. The average duration of the second syllable is 6.4 ± 1.0 ms (4.7–9.4 ms). The average down time (silent interval between the two syllables) is 14.0 ± 1.4 ms (10.8–16.9 ms). The average period of syllable is 18.6 ± 0.9 ms (15.7–20.4 ms). The first syllable is usually of a slightly lower amplitude than the last pulse of the second syllable. The frequency spectrum is broadband and is not symmetrical and has a peak frequency of 23.5 ± 0.8 kHz (22.0–24.7 kHz). The spectrum also has a secondary peak at 10.8 ± 0.5 kHz (10.2–11.3 kHz).

Elbenia (Elbenia) ?tenera Brunner von Wattenwyl, 1878

(Figs 2B, 5–7)

Elbenia tenera Brunner von Wattenwyl, 1878: 166—Brunner von Wattenwyl, 1891: 78; Brunner von Wattenwyl, 1898: 254; Kirby, 1906: 425; Hebard, 1922: 143.

Elbenia triangularis Brunner von Wattenwyl, 1898: 255—Kirby, 1906: 425; Hebard, 1922: 143 (synonymisation); Tan, 2014: 333; Gorochov, 2023b: 9, 24; Tan *et al.*, 2024a: 457.



FIGURE 5. *Elbenia (Elbenia) ?tenera* Brunner von Wattenwyl, 1878 in its natural environment at Sinipung Hill.

New material examined. EAST MALAYSIA; Sabah State • 2♂; Sinipung Hill, near Long Pasia and Meligan; N4.42605 E115.72710, 1177.0±5.3 m.a.s.l.; 20 November 2024, 13h03; resting on *Melastoma* leaf; coll. M.K. Tan; SBH.24.152, 153 (ZRC) • 1♂; Sinipung Hill, near Long Pasia and Meligan; N4.42801 E115.72686, 1188.0±6.8 m.a.s.l.; 20 November 2024, 13h20; flying around in open area; coll. M.K. Tan; SBH.24.154 (FRC) • 1♂; Meligan (P28 a.k.a. pt 2); N4.57441 E115.73289, 1374.0±6.5 m.a.s.l.; 23 November 2024, 19h49; on foliage of rattan; coll. M.K. Tan; SBH.24.234 (Fig. 5) (ZRC) • 4♂; Meligan (P28 a.k.a. pt 2); N4.57619 E115.73923, 1266.0±6.8 m.a.s.l.; 23 November 2024, 22h00; attracted to light trap on the road; coll. M.K. Tan; SBH.24.255, 256, 259, 260 (MNHN and ZRC) • 1♀; Sinipung Hill, near Long Pasia and Meligan; N4.42267 E115.72818, 1153.0±5.8 m.a.s.l.; 20 November 2024, 12h28; flying around in open area; coll. M.K. Tan; SBH.24.151 (FRC).

Remarks. Our male specimens (Fig. 6) resemble the specimens described in Gorochov (2023b): the male tenth abdominal tergite extends posteriorly, forming a large hammerhead-like extension at the apex, with each end having dorsal and ventral lobes; but this extension is a little disproportional in our specimens compared to the ones by Gorochov (2023b). Their cerci are similar in being simple, small, more strongly curved subapical parts and with the very small apical parts curved medially and having the apex sclerotized and slightly falcate (Figs. 6D–F). The subgenital plate is very large, elongated, curved dorsad at the apical half, narrowly but deeply emarginated, at the apex each with two (sometimes with additional one) tooth-like denticles (Figs. 6D–F).

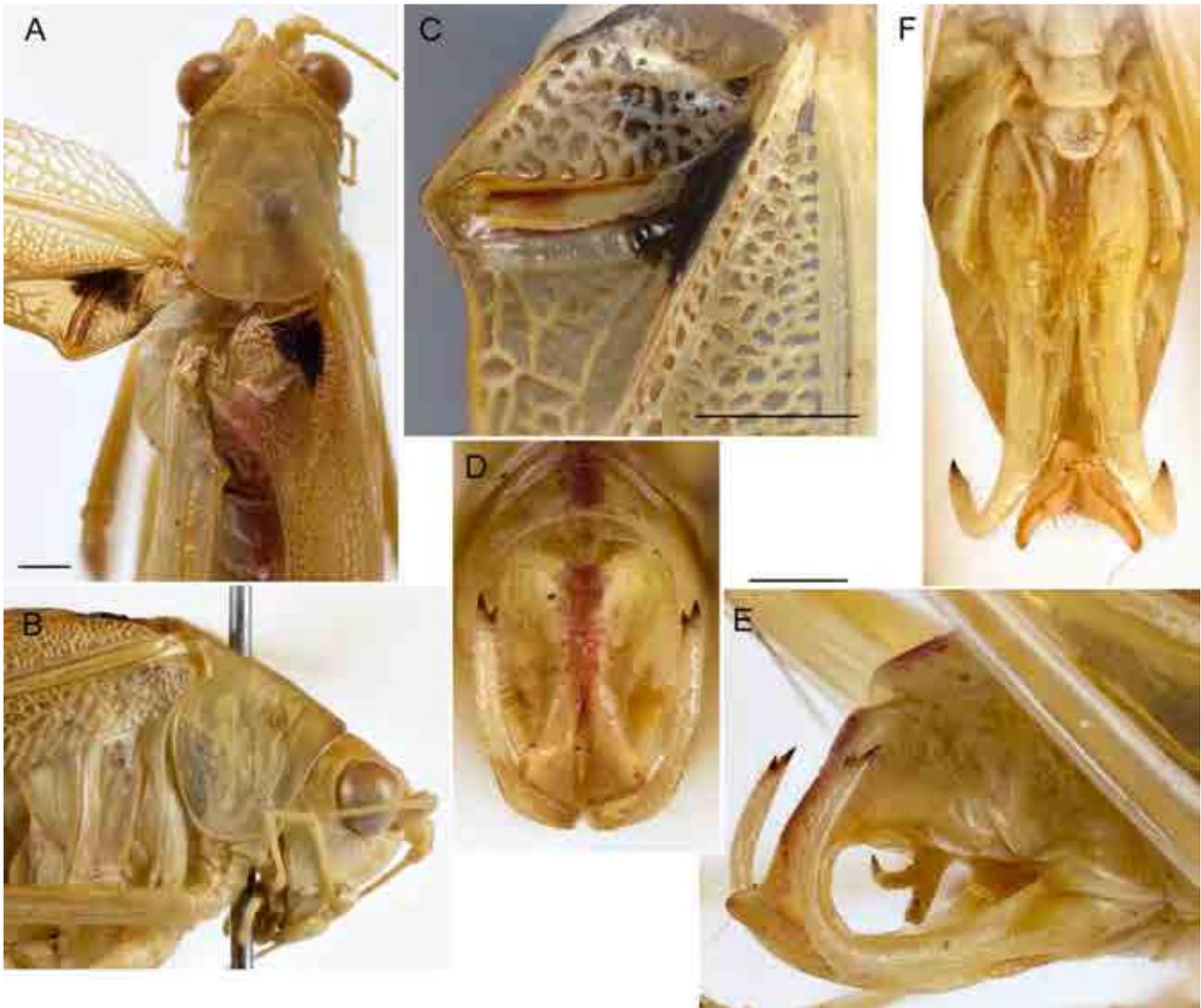


FIGURE 6. *Elbenia (Elbenia) tenera* Brunner von Wattenwyl, 1878: head, pronotum and anterior parts of tegmina in dorsal (A) and lateral (B) views; stridulatory area of the left tegmen in ventral view (C); abdominal apex in posterior (D), postero-lateral (E) and ventral (F) views. Scale bars: 1 mm.

Type locality. Borneo.

Natural history. This species is very common at the forest edge and can be found flying around even in the day.

Calling song (Fig. 7). The calling song is an isolated echeme made up of 3–7 isolated syllables, with an average of 4 ± 1 syllables. The average echeme duration is 0.42 ± 0.16 s (0.19–0.78 s). Within each echeme, the average syllable duration is 4.0 ± 1.0 ms (2.5–6.0 ms) and the average down time (silent interval between the two syllables) is 0.13 ± 0.02 s (0.09–0.17 s). On rare occasions, doublet of syllables may occur. The frequency spectrum is broadband and is not symmetrical and has a peak frequency of 18.9 ± 1.5 kHz (17.3–23.0 kHz).

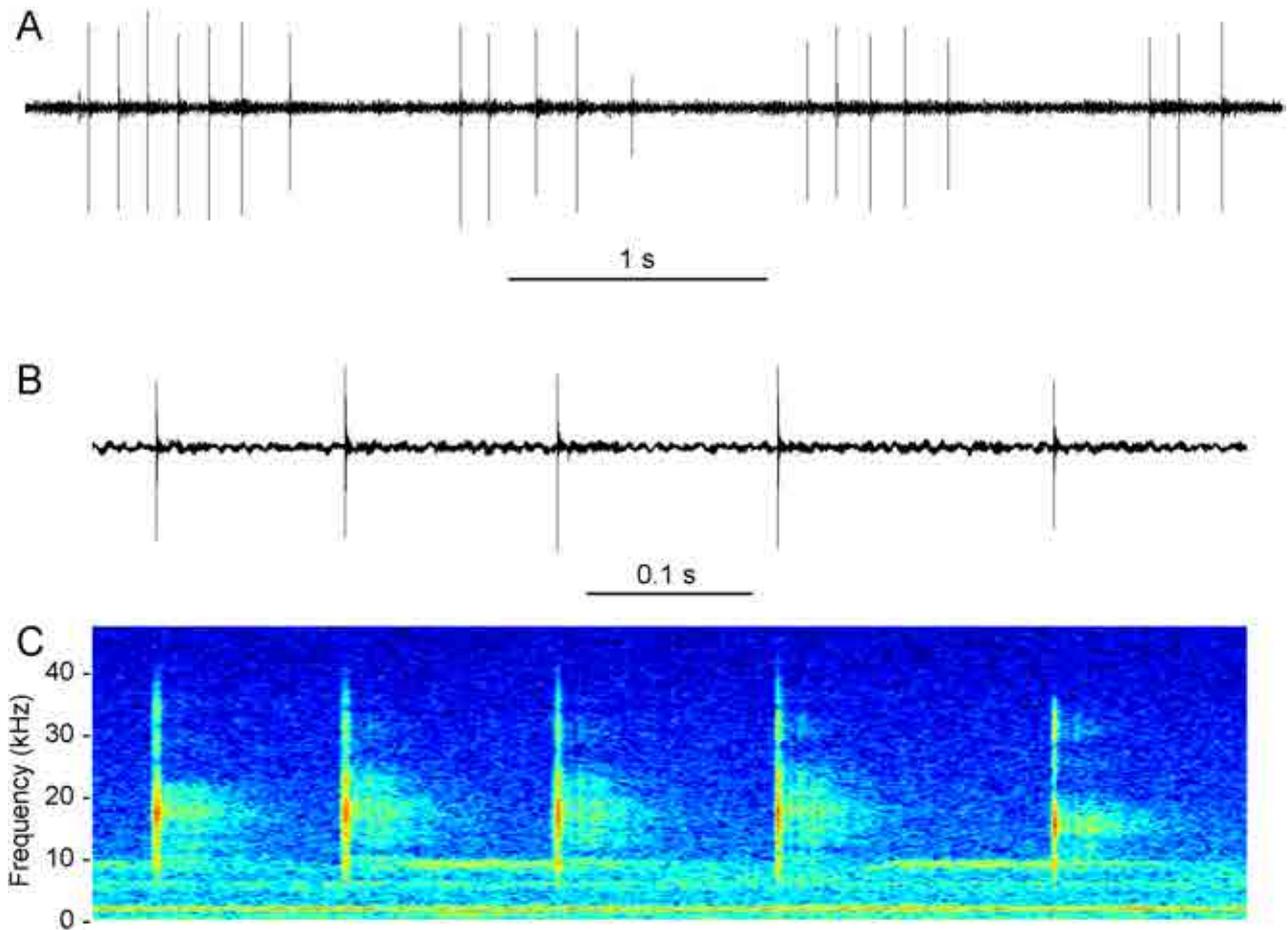


FIGURE 7. *Elbenia (Elbenia) tenera* Brunner von Wattenwyl, 1878 male calling song: oscillograms showing four echemes (A) and one echeme with five syllables (B); spectrogram showing the same echeme (C).

***Holochlora falcata* Tan, Liu & Ingrisch, 2024**

(Figs 2C, 8)

Holochlora falcata Tan, Liu & Ingrisch, 2024 in Tan *et al.*, 2024a: 464.

New material examined. EAST MALAYSIA; Sabah State • 1♂; Maliau Basin Conservation Area, at Maliau Basin Studies Centre accommodation (Keruing); N4.73588 E116.97442; 17 November 2024, evening; attracted to light; coll. M.K. Tan; SBH.24.137 (ZRC).

Remarks. First described from Mount Trus Madi, the new material collected in Maliau Basin represents a new locality record.

Type locality. EAST MALAYSIA: Sabah: Mount Trus Madi.

Distribution. Borneo: Sabah State: Mount Trus Madi, Maliau Basin [new locality record].

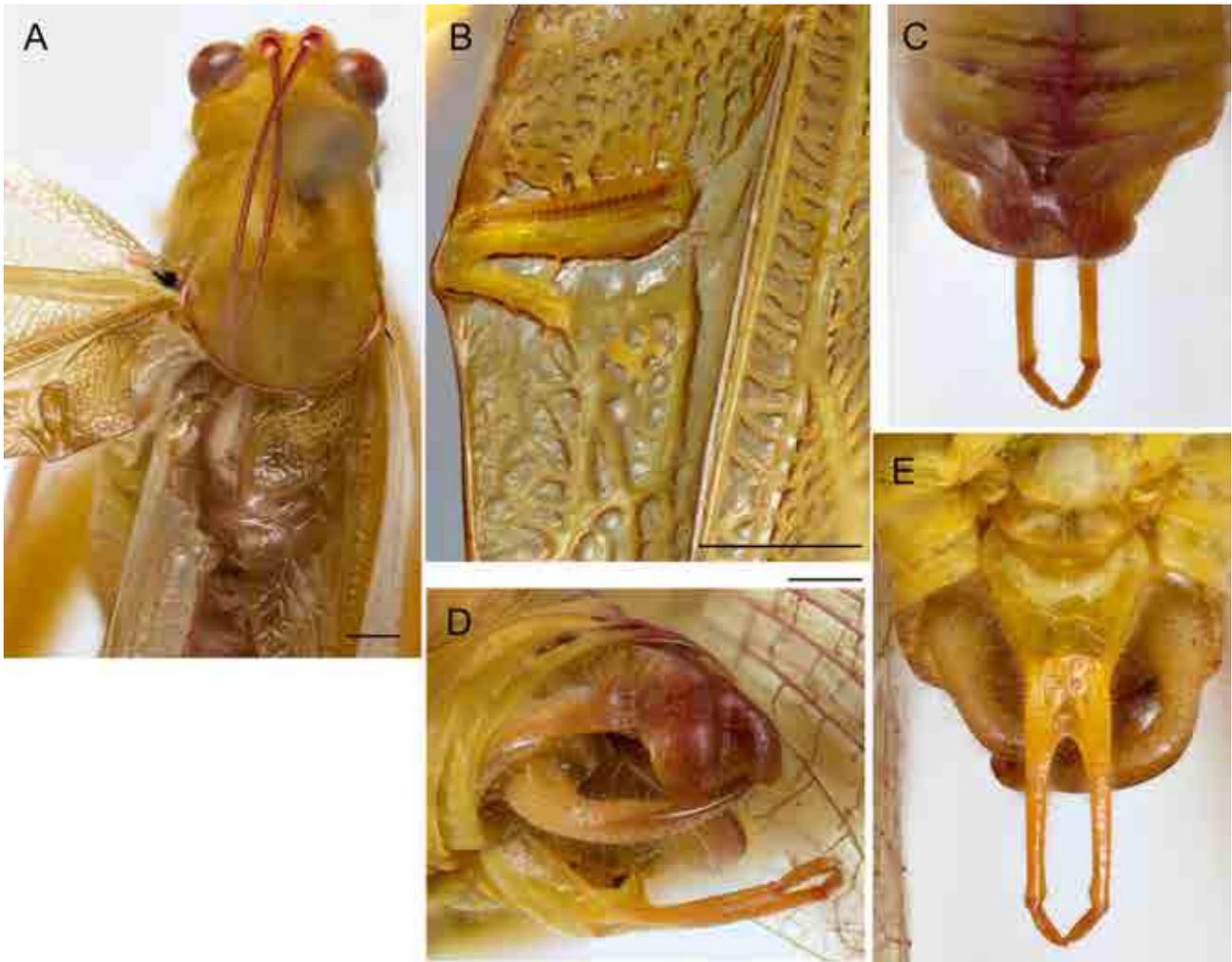


FIGURE 8. *Holochlora falcata* Tan, Liu & Ingrisch, 2024: head, pronotum and anterior parts of tegmina in dorsal view (A); stridulatory area of the left tegmen in ventral view (B); abdominal apex in dorsal (C), postero-lateral (D) and ventral (E) views. Scale bars: 1 mm.

***Psyrana (Psyrana) nr. imitativa* Gorochov, 2024**

(Figs 2D, 9)

Psyrana (Psyrana) imitativa Gorochov, 2024: 739.

New material examined. EAST MALAYSIA; Sabah State • 2♂; Maliau Basin Conservation Area, at Maliau Basin Studies Centre accommodation (Keruing); N4.73588 E116.97442; 17 November 2024, evening; attracted to light; coll. M.K. Tan; SBH.24.139, 147 (ZRC).

Remarks. Our specimens from Maliau Basin (Fig. 9) show similarities with *Ps. (Ps.) melanonota* (Stål, 1876) from Sumatra and Malay Peninsula, *Ps. (Ps.) imitativa* Gorochov, 2024 from Mindanao (Philippines) and *Ps. (Ps.) simulator* Gorochov, 2024 from Sabah (Borneo). The dark colouration and patterns on the pronotum most resemble *Ps. (Ps.) melanonota*, but our specimens differ from all three species by the dorsum of the head completely red, instead of having merely red patterns as in *Ps. (Ps.) imitativa* or limited to only the upper rostral tubercle. Each tegmen has a conspicuous reddish stripe along the proximal branch of the Sc vein, resembling those in *Ps. (Ps.) imitativa* rather than *Ps. (Ps.) melanonota*. The left stridulatory area of our specimens is mostly similar to that of *Ps. (Ps.) simulator* in the shape and relative size of the mirror, but is most similar to *Ps. (Ps.) imitativa* in the shape of the stridulatory file. The male cercus resembles *Ps. (Ps.) imitativa* and *Ps. (Ps.) simulator* more than *Ps. (Ps.) melanonota* by the shorter relative distance between the two apical and preapical teeth. The male subgenital plate

resembles *Ps. (Ps.) melanonota* and *Ps. (Ps.) imitativa* by the apical notch deeper than that in *Ps. (Ps.) simulator*. These suggest that the three species and our specimens may possibly represent a single species or part of a species complex. Here, we tentatively identify our specimens as *Ps. (Ps.) imitativa* owing to the overall similarities in the stridulatory file on the left tegmen, cercus, and male subgenital plate.

Type locality. PHILIPPINES: Bazilan Island.

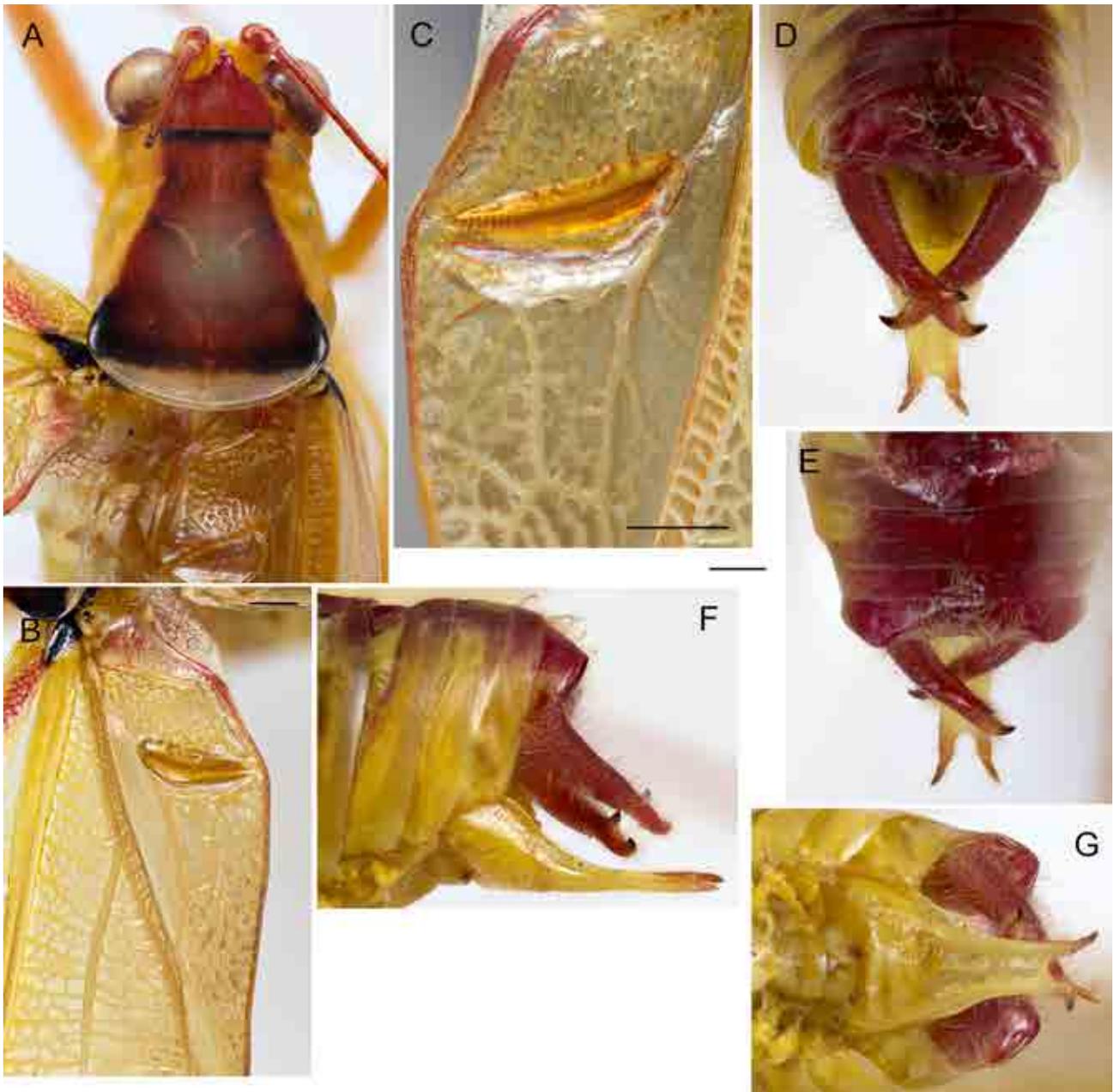


FIGURE 9. *Psyrana (Psyrana) nr. imitativa* Gorochov, 2024: head, pronotum and anterior parts of tegmina in dorsal view (A); stridulatory area of the left tegmen in dorsal (B) and ventral (C) views; abdominal apex in dorso-posterior (D), dorsal (E), lateral (F) and ventral (G) views. Scale bars: 1 mm.

***Rectimarginalis ensis* (Haan, 1843)**

(Figs 2E, 10, 11)

Locusta (Phaneroptera) ensis Haan, 1843: 191, 194.

Psyrans ensis (Haan, 1843) in Brunner von Wattenwyl, 1878: 171—Kirby, 1906: 427; Karny, 1923: 155.

Holochlora ensis (Haan, 1843) in Karny, 1925: 40—Karny, 1926a: 120; Karny, 1926b: 103; Otte, 1997: 134.
Rectimarginalis ensis (Haan, 1843) in Liu & Kang, 2007: 190—Tan, 2014: 587; Tan *et al.*, 2019: 320.

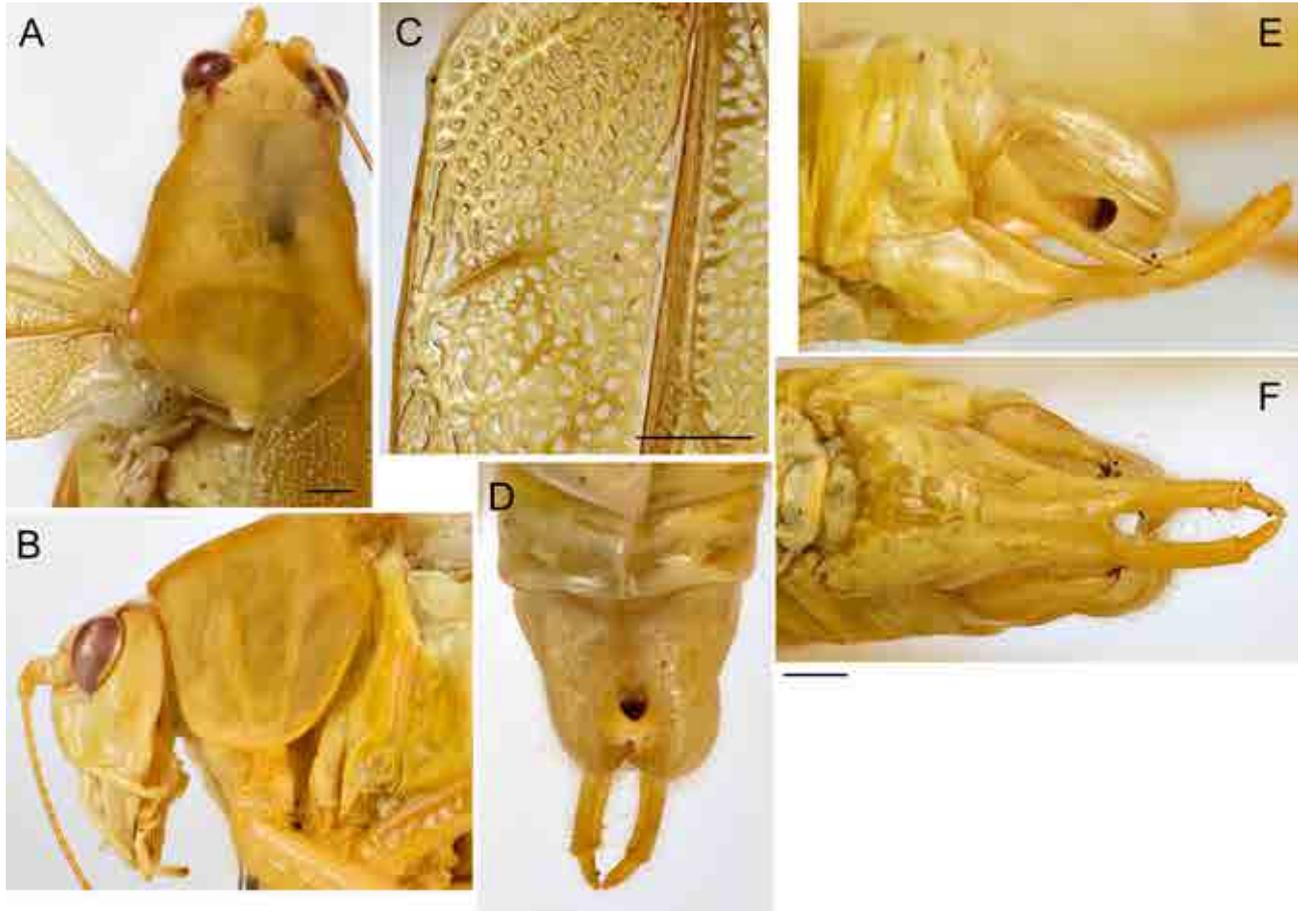


FIGURE 10. *Rectimarginalis ensis* (Haan, 1843): head, pronotum and anterior parts of tegmina in dorsal (A) and lateral (B) views; stridulatory area of the left tegmen in ventral view (C); abdominal apex in dorsal (D), lateral (E) and ventral (F) views. Scale bars: 1 mm.

New material examined. EAST MALAYSIA; Sabah State • 2♂; Maliau Basin Conservation Area, at Maliau Basin Studies Centre dining area; N4.73668 E116.97468; 17 November 2024, 19h00; attracted to light; coll. M.K. Tan; SBH.24.126, 129 (ZRC) • 1♂; Maliau Basin Conservation Area, at Maliau Basin Studies Centre accommodation (Keruing); N4.73588 E116.97442; 17 November 2024, evening; attracted to light; coll. M.K. Tan; SBH.24.136 (ZRC).

Type locality. Borneo.

Calling song (Fig. 11). The calling song is an isolated echeme made up of an average of 4 ± 1 syllables (3–5 syllables), although on rare occasions, the echeme can also be made up of up to 8 and 9 syllables. The average echeme duration is 0.27 ± 0.05 s (0.17–0.37 s). Within each echeme, the average syllable duration is 9.4 ± 1.8 ms (5.8–13.1 ms) and the average down time (silent interval between the two syllables) is 77.1 ± 10.9 ms (63.4–111.5 ms). The average period of syllable is 86.5 ± 10.2 ms (74.1–119.9 ms). The frequency spectrum is broadband and is not symmetrical and has a peak frequency of 9.83 ± 0.87 kHz (7.59–10.97 kHz).

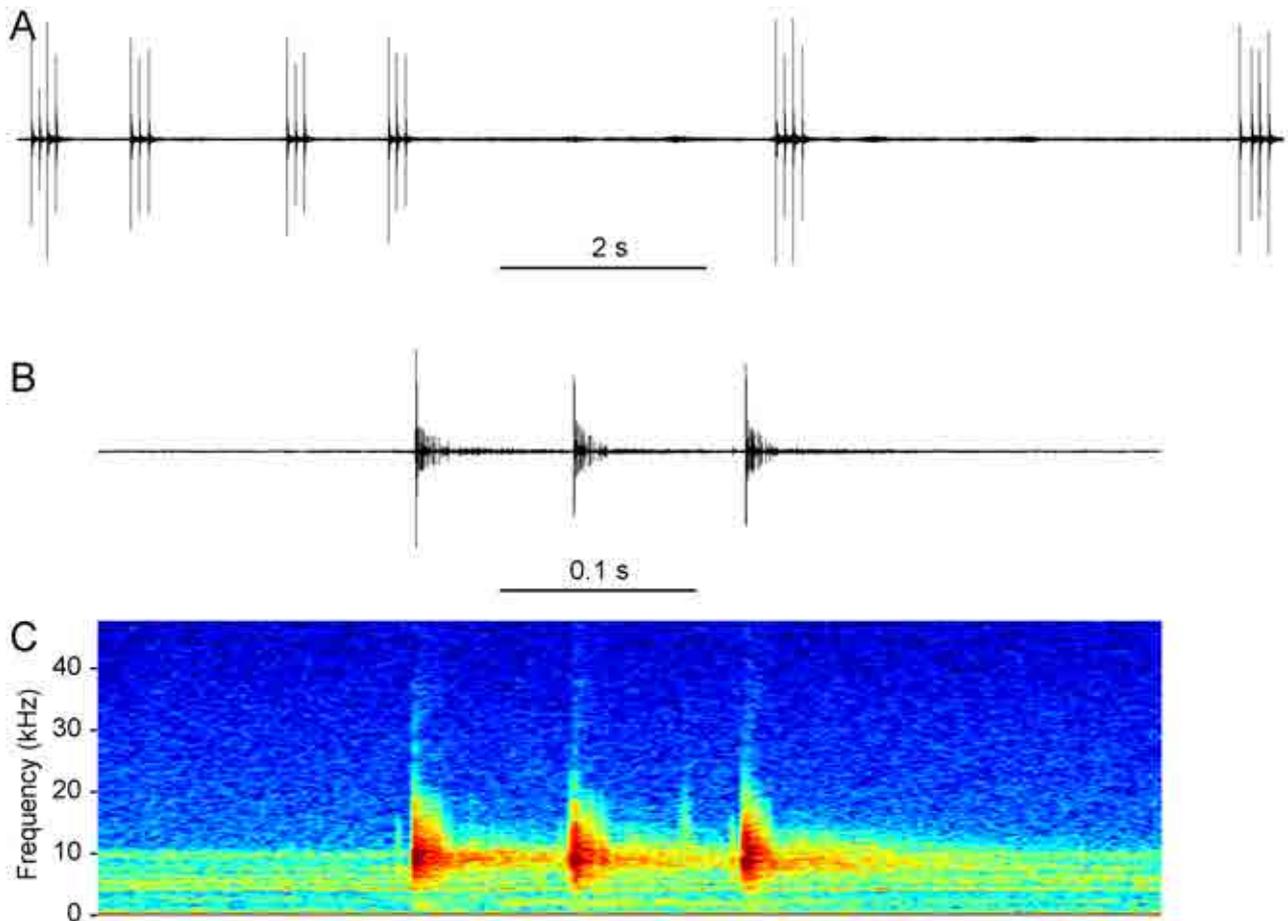


FIGURE 11. *Rectimarginalis ensis* (Haan, 1843) male calling song: oscillograms showing six echemes (A) and one echeme with three syllables (B); spectrogram showing the same echeme (C).

***Stictophaula multa* Gorochov & Voltshenkova, 2009**

(Figs 2F, 12)

Stictophaula multa Gorochov & Voltshenkova, 2009: 72—Tan & Wahab, 2017: 305; Tan *et al.*, 2024a: 477.

New material examined. EAST MALAYSIA; Sabah State • 1♂; Sinipung Hill, near Long Pasia and Meligan; N4.44538 E115.71494, 1558.0±9.9 m.a.s.l.; 21 November 2024, 22h30; foliage of small tree near to light trap; coll. M.K. Tan; SBH.24.214 (ZRC).

Remarks. Our single male specimen mostly resembles *S. multa* Gorochov & Voltshenkova, 2009. Its male subgenital plate at its posterior end has lateral lobes that are elongated and slender and medial lobes that are very primitive, almost like nodules, not different from *S. multa*. But in our specimen, the medial lobes are situated at the middle of the posterior margin distinctly apart from lateral lobes (Figs 12C, 12D), unlike that illustrated in Gorochov & Voltshenkova (2009). The median sclerite of the male genitalia is most similar to that of *S. multa* as suggested by the slender and elongated shape (in ventral view) and bent at nearly 90° (in lateral view) (Figs 12E–G). It is similar to *Stictophaula aspersa* Gorochov & Voltshenkova, 2009 from Mount Trus Madi and *Stictophaula bruneii* Tan & Wahab, 2017 from Brunei Darussalam, but slenderer and more elongated at apex (in ventral view). The stridulatory area, including the dark patterns on both tegmina, sinuous shape of the stridulatory file (Fig. 12B) and shape of mirror on the right tegmen, resembles *S. multa* more than *S. aspersa* and *S. bruneii*.

Type locality. EAST MALAYSIA: Sabah: Mount Trus Madi.

Distribution. Borneo: Sabah State: Mount Trus Madi, Sinipung Hill [new locality record].

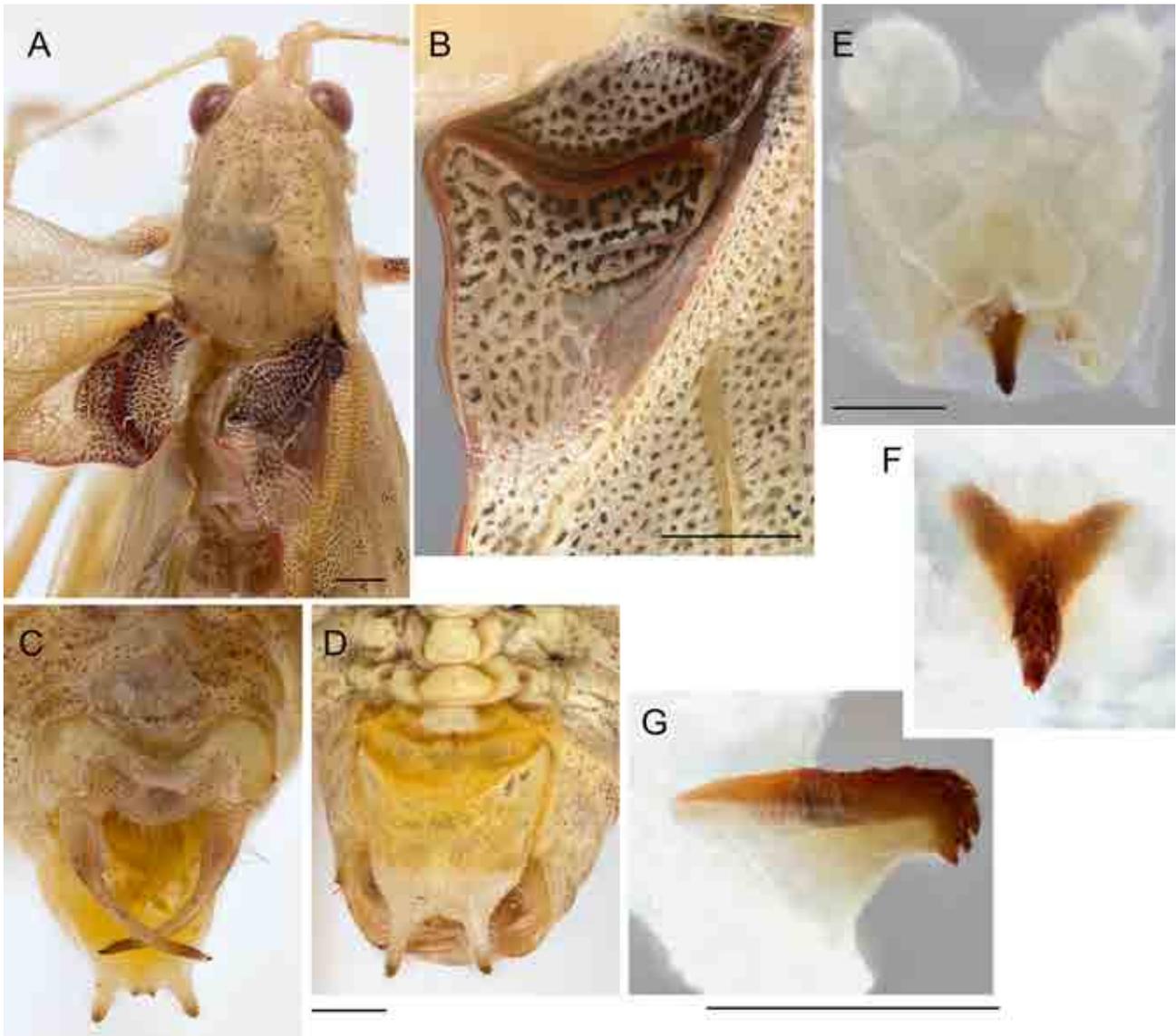


FIGURE 12. *Stictophaula multa* Gorochov & Voltshenkova, 2009: head, pronotum and anterior parts of tegmina in dorsal view (A); stridulatory area of the left tegmen in ventral view (B); abdominal apex in dorsal (C) and ventral (D) views; the male genitalia (median sclerite with membranous parts) in dorsal (E), median sclerite in ventro-posterior (F) and lateral (G) views. Scale bars: 1 mm.

***Tapiena ?incisa* Karny, 1923**

(Figs 2G, 13–15)

Tapiena incisa Karny, 1923: 141—Tan *et al.*, 2015: 42, 43 (key); Tan *et al.*, 2019: 328 (wrong identification); Tan *et al.*, 2024a: 481.

New material examined. EAST MALAYSIA; Sabah State • 2♂; Sinipung Hill, near Long Pasia and Meligan; N4.44538 E115.71494, 1556.0±10.1 m.a.s.l.; 21 November 2024, 21h30; attracted to light trap; coll. M.K. Tan; SBH.24.205, 206 (ZRC) • 2♂; Meligan (P28 a.k.a. pt 2); N4.57619 E115.73923, 1266.0±6.8 m.a.s.l.; 23 November 2024, 22h00; attracted to light trap on the road; coll. M.K. Tan; SBH.24.268, 269 (Fig. 13) (ZRC).



FIGURE 13. *Tapiena ?incisa* Karny, 1923 when alive, in captivity.

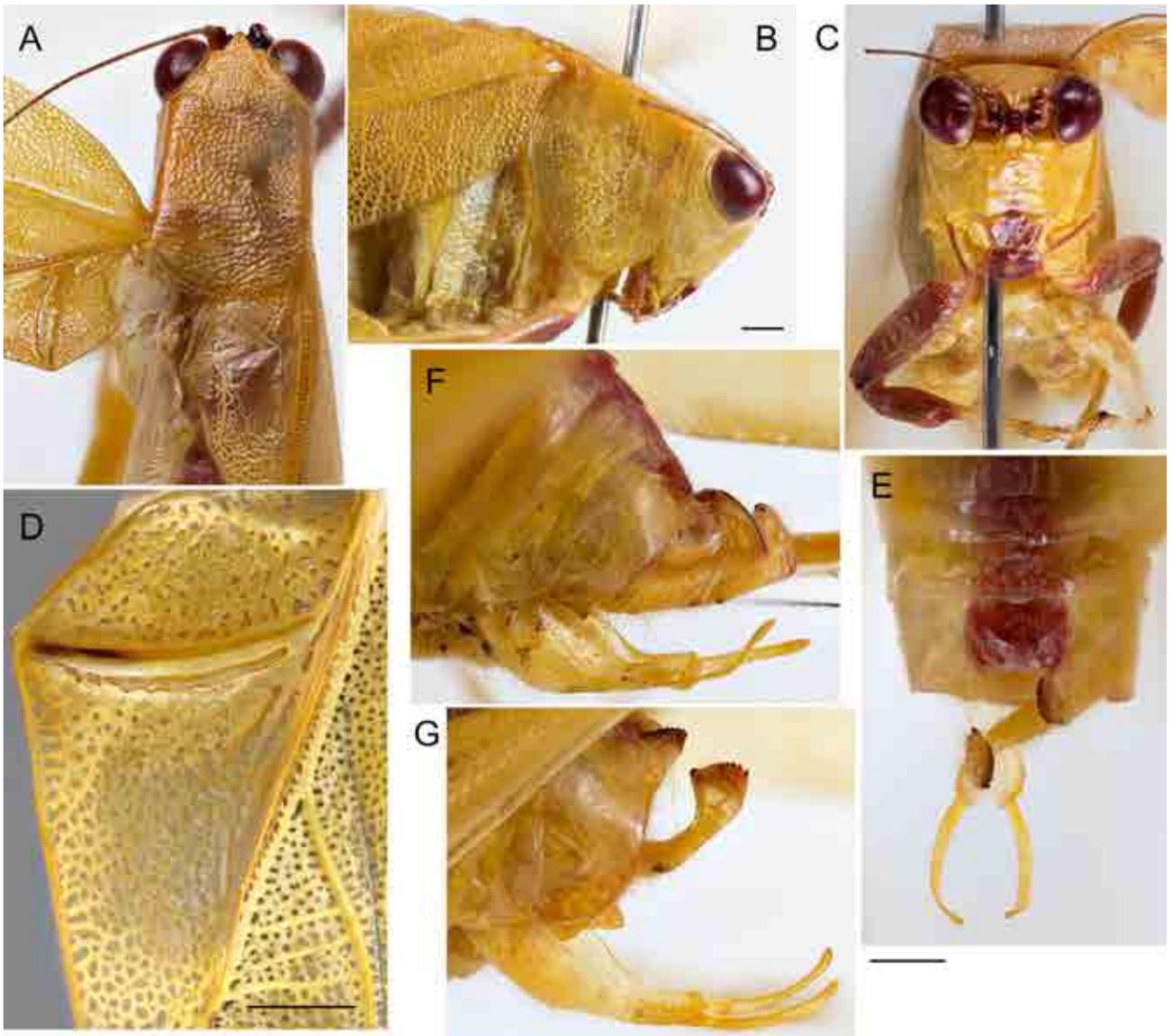


FIGURE 14. *Tapiena ?incisa* Karny, 1923: head, pronotum and anterior parts of tegmina in dorsal (A), lateral (B) and anterior (C) views; stridulatory area of the left tegmen in ventral view (D); abdominal apex in dorsal (E) and lateral (F, G) views. Scale bars: 1 mm.

Remarks. Our specimens resemble those collected from Mount Trus Madi by Tan *et al.* (2024a) and northwestern Kinabalu (Muhammad & Tan, 2025) in the important species characters, including the shapes of the male cercus, tenth abdominal tergite and subgenital plate, as well as the shape of the stridulatory areas (Fig. 14). Our specimens also resemble *Tapiena bullata* Karny, 1923 from Malay Peninsula, particularly in the shape of the apex of their cercus.

Type locality. EAST MALAYSIA: Sarawak: Baram River, Gunong Tamabo.

Calling song (Fig. 15). The calling song is an isolated echeme made up of an average of 11–12 closely-spaced syllables. The average echeme duration is 0.70 ± 0.10 s (0.58–0.79 s). Within each echeme, the amplitudes of the syllables increase to a maximum; the average syllable duration is 13.7 ± 1.4 ms (12.2–15.3 ms) and the average down time (silent interval between the two syllables) is 48.6 ± 7.1 ms (40.7–54.5 ms). The average period of syllable is 62.3 ± 5.8 ms (55.7–67.4 ms). The frequency spectrum is broadband and is not symmetrical and has a peak frequency of 13.82 ± 0.83 kHz (13.41–14.16 kHz).

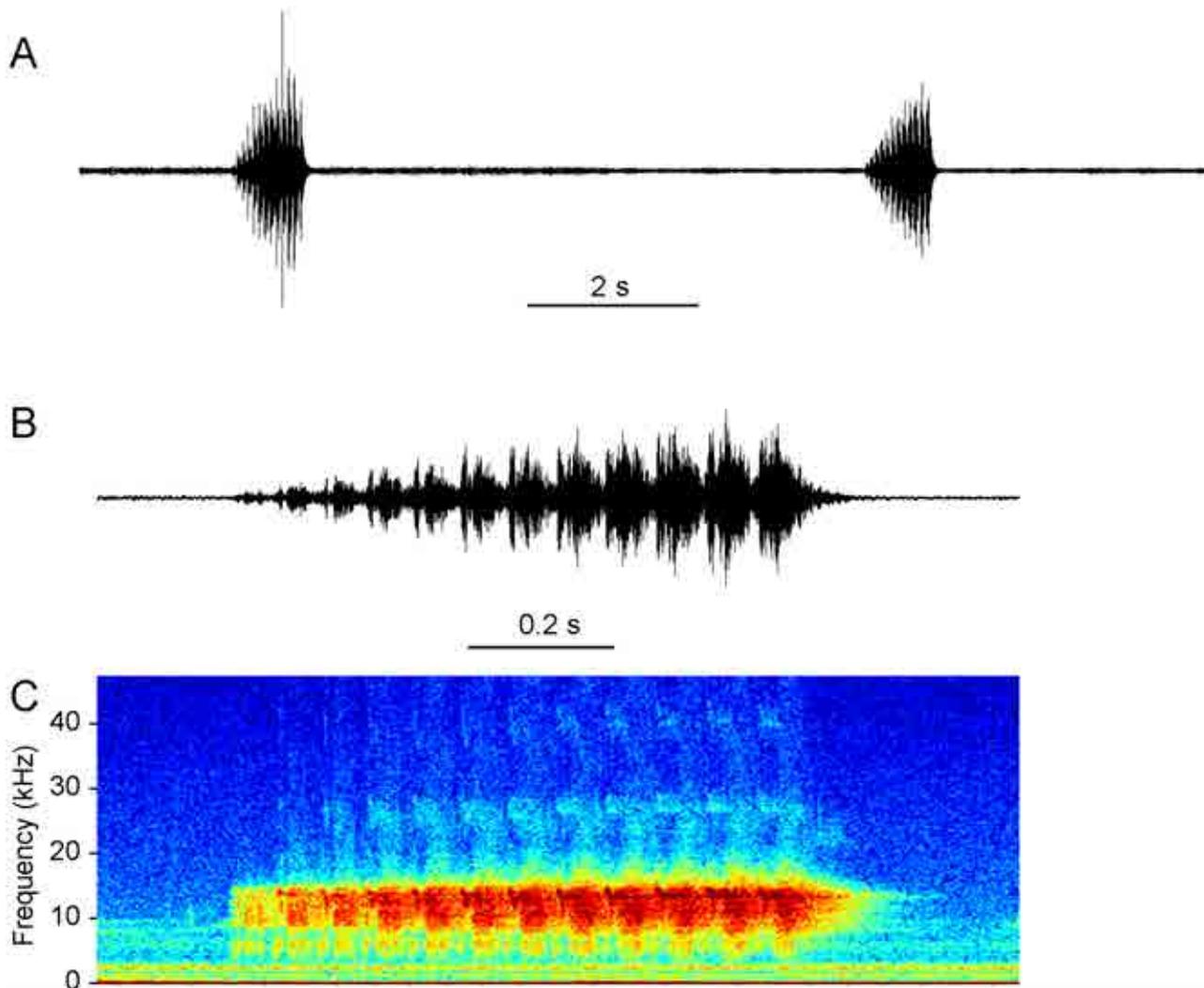


FIGURE 15. *Tapiena ?incisa* Kary, 1923 male calling song: oscillograms showing two echemes (A) and one echeme with 12 syllables (B); spectrogram showing the same echeme (C).

***Tapiena dimidia* sp. nov.**

(Figs 16–18)

Material examined. Holotype. EAST MALAYSIA; Sabah State • ♂; Maliau Basin Conservation Area, at Maliau Basin Studies Centre accommodation (Keruing); N4.73588 E116.97442; 17 November 2024, evening; attracted to light; coll. M.K. Tan; SBH.24.143 (FRC).

Paratype. EAST MALAYSIA; Sabah State • 1♂; Maliau Basin Conservation Area, at accommodation (Keruing); 17 November 2024, evening; attracted to light; coll. M.K. Tan; SBH.24.146 (ZRC).

Diagnosis. The new species is characterised by the following characters: stout habitus, fore femur and tympanum red, the stridulatory file on the left tegmen has two sets of distinctly different-sized teeth (at its anal half having stouter teeth more widely spaced apart; and at its basal half having slenderer teeth that are more closely spaced together); the male tenth abdominal tergite forms a simple red transverse plate with the posterior margin truncated and slightly emarginated in the middle, instead of an apical process highly modified into a large laterally compressed plate; its cercus elongated, slender, and arcuate with its apex tapering into a small acute claw-like tooth and an even smaller spine.



FIGURE 16. Habitus of *Tapiena dimidia* sp. nov. in dorsal (A, B) and lateral (C, D) views of holotype (A, C) and paratype (B, D). Scale bar: 10 mm.

The new species is generally similar to *Tapiena paraincisa* Tan & Wahab, 2018 from Brunei Darussalam and *Tapiena ?incisa* Karny, 1923 from Sabah by its stout habitus, its fore femur and tympanum red and the tenth abdominal tergite incised in the middle along the hind margin; but it differs by the long, arcuate and slender cercus with the apex having a small acute claw-like tooth and an even smaller spine (instead of a stouter cercus with a larger apical tooth blade-shaped, smaller tooth originating base of apical tooth in *T. paraincisa* and instead of having a flattened apex with denticulated margin in *T. ?incisa*); and the teeth distribution on the stridulatory file of the left tegmen.

The new species is similar to *Tapiena denticulata* Tan, Liu & Artchawakom, 2015 from Thailand by the long, arcuate and slender cercus and its tenth abdominal tergite simple plate-like; but differs by the apex of the cercus simple and having a small acute claw-like tooth and an even smaller spine (instead of acute and sclerotized and having its dorsal margin denticulate), the tenth abdominal tergite red and slightly emarginated in the middle (instead of green and not emarginated and more posteriorly produced), its fore femur and tympanum red (instead of green).

Etymology. The species name refers to the characteristics stridulatory file made up of two halves of distinctly different-sized teeth; dimidius = half, in Latin.

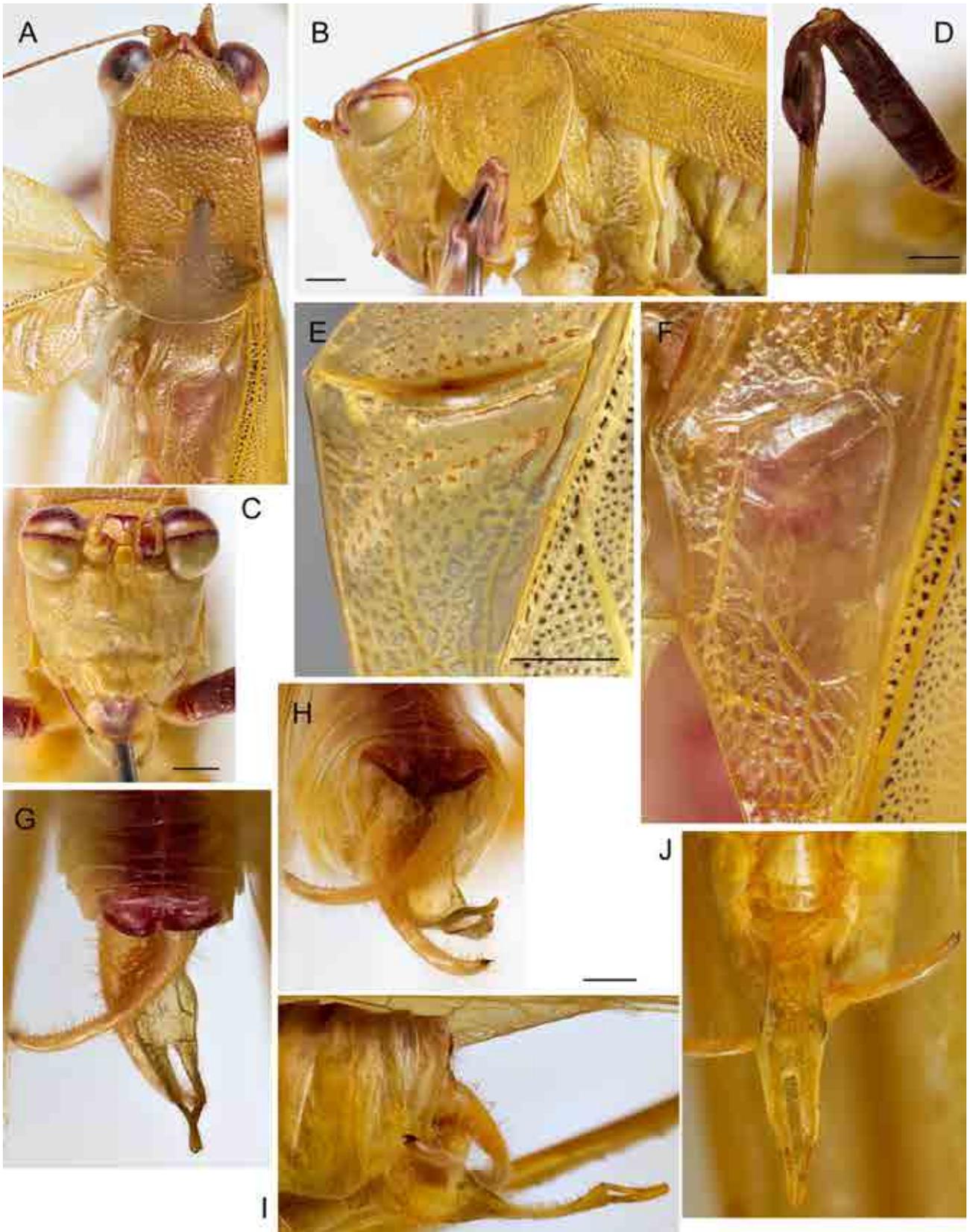


FIGURE 17. *Tapiena dimidia* sp. nov.: head, pronotum and anterior parts of tegmina in dorsal (A), lateral (B) and anterior (C) views; fore femur and inner tympanum (D); stridulatory area of the left (E) and right (F) tegmina in ventral and dorsal views, respectively; abdominal apex in dorsal (G), posterior (H), lateral (I) and ventral (J) views. Scale bars: 1 mm.

Description. Habitus as shown in Fig. 16. Head (with frons and vertex), pronotum, pleurae and tegmina densely and regularly covered with punctures, typical for genus (Figs 17A–C). Fastigium in dorsal view narrowly triangular, short, feebly surpassing anterior apex of eyes; furrowed longitudinally; at sulcus as wide as antennal scapus; with apex roundly truncated (Fig. 17A). Eye prominent, in dorsal view slightly protruding anteriorly (Fig. 17A); median and lateral ocelli prominent, round and large (Fig. 17C). Frons slightly punctuated (Fig. 17C); dorsum of head (Fig. 17A) and genae (Fig. 17B) densely punctuated. Pronotum circa 1.1–1.2 times longer than wide, densely punctuated (Figs. 17A). Dorsal disc with anterior margin straight; lateral margins straight and nearly parallel (feebly diverging posteriorly); posterior margin broadly rounded; hind lobe after middle, separated by shallow suture; longitudinal furrow absent (Fig. 17A). Lateral keel present. Lateral lobe 1.4 times as tall as long; ventral margin short, anterior and posterior margins substraight (Fig. 17B). Thoracic auditory spiracle [= thoracic foramen] covered by pronotal lateral lobe (Fig. 17B). Prosternum unarmed. Mesosternum triangular with subacute apex; metasternum rectangular with anterior angle obtusely rounded, posterior angle 90° and rounded. Tegmen and hind wing fully developed. Hind wing with apex distinctively projecting beyond tegmen; exposed apex with dorsal and ventral margins straight and tapering to subacute apex (Fig. 16). Legs generally with very short and fine setae. Fore coxa with distinct, long, rather straight (only slightly curved at base) spine. Fore tibia with external tympanum open, oval; internal tympanum slit covered by large conchate swelling (Fig. 17D). Hind femur with genicular lobe rounded, without any spine.

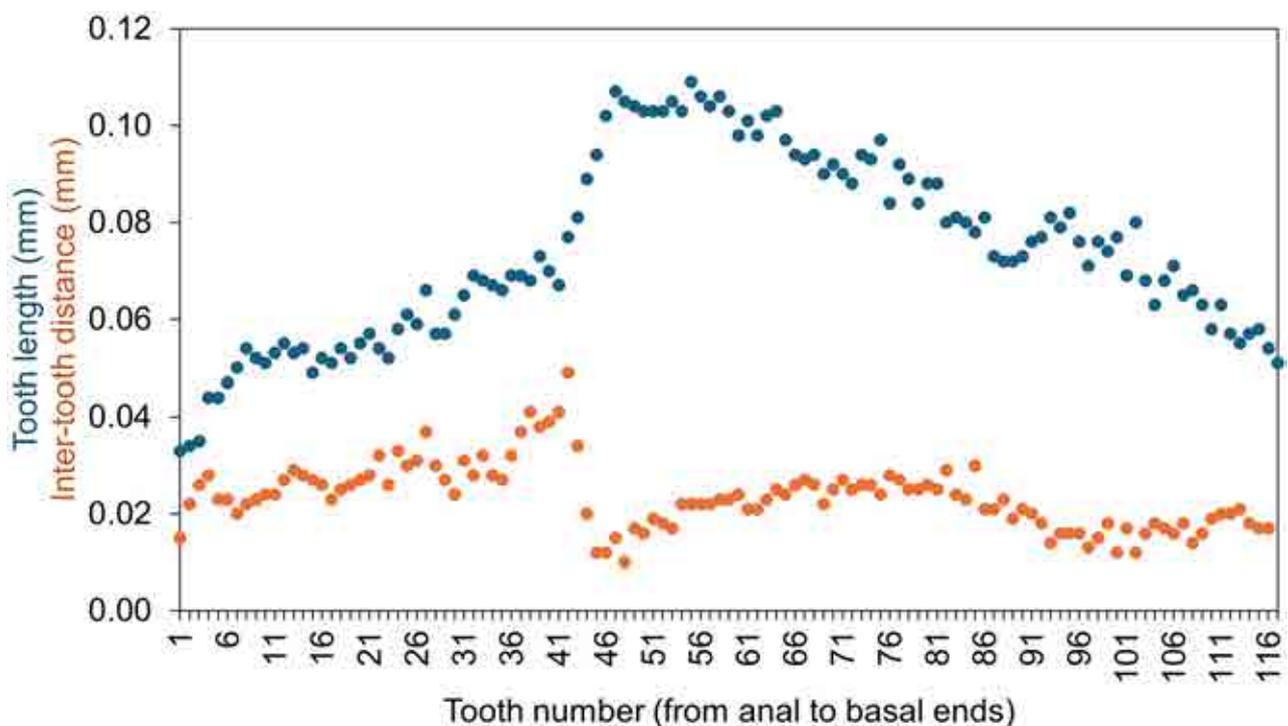


FIGURE 18. *Tapiena dimidia* sp. nov. tooth distribution on the stridulatory file of the left tegmen based on tooth length (blue) and inter-tooth distance (orange).

Male. Tegmen with anterior and posterior margins feebly convex, feebly widened in the middle before tapering to rounded apex; punctuated with many small transparent cells. Tegminal venation: Radius sector (Rs) originating at mid-length, with fork longer than stem (Fig. 16A). Stridulatory file of left tegmen transversely crescent-shaped, 2.6 mm in length (Fig. 17E); area around file not swollen; file made up of two sets of distinctly different-sized teeth; at anal half 1.16 mm in length with 43 stouter teeth more widely spaced apart (average inter-tooth distance is 0.027 mm per tooth), and at basal half 1.48 mm in length with 75 slenderer teeth more closely spaced together (average inter-tooth distance is 0.020 mm per tooth) (Figs 17E, 18). Mirror on left tegmen made up of network of inter-crossed veins, parallelogram in shape, with anterior margin distinctly longer than posterior margin (Fig. 17E). Mirror on right tegmen longer than broad, pentagonal in shape (Fig. 17F).

Tenth abdominal tergite simple, with little or no modification, without tooth or long process apically; forming simple red transverse plate with posterior margin truncated and slightly emarginated at middle (Figs 17G, 17H). Epiproct concealed beneath tenth abdominal tergite. Cercus long, slender, cylindrical and setose, arcuate with apex

tapering into tooth small acute claw-like and spine even smaller triangular and stout (Figs 17G–I). Subgenital plate very wide basally, tapering sharply into very narrow shaft; anterior margin concave; posterior margin deeply and truncated excised at middle, laterally extended into two long and narrow lobes; styli relatively short, slightly shorter than apical excision of subgenital plate, tapering into obtuse apex (Fig. 17J).

Female. Unknown.

Colouration. Generally green when alive, except frontal rostrum and inner part of scapus, labrum, apical segment of maxillary palps having tints of red (Figs 17A, 17B). Fore coxa (apical part), fore femur and anterior half of fore tibia (including tympanum) red; area around tympanum black (Fig. 17D). Tergites at middle red; tenth abdominal tergite red (Figs 17G–I).

Measurements (in mm). See Table 1.

***Tapiena munae* sp. nov.**

(Figs 19–21)

Material examined. Holotype. EAST MALAYSIA; Sabah State • 1♂; Sinipung Hill, near Long Pasia and Meligan; N4.44538 E115.71494, 1556.0±10.1 m.a.s.l.; 21 November 2024, 21h30; attracted to light trap; coll. M.K. Tan; SBH.24.204 (FRC).

Paratype. EAST MALAYSIA; Sabah State • 1♂; Sinipung Hill, near Long Pasia and Meligan; N4.43477 E115.72321, 1290.0±7.0 m.a.s.l.; 20 November 2024, 19h36; on foliage of small tree; coll. M.K. Tan; SBH.24.181 (ZRC).

Diagnosis. The new species has a stout habitus and is characterised by the following characters: its face is red, from the fastigium to the frons, clypeus and labrum; the male tenth abdominal tergite forms a simple plate with two triangular lateral lobes (with rounded apices) and has its posterior margin between the lateral lobes truncated and roundly excised in the middle; the cercus is stout, bent at the middle (instead of arcuated) with its apex having three tooth-like spines.

The new species is generally similar to *T. paraincisa*, *Tapiena ?incisa* and *Tapiena dimidia* **sp. nov.** owing to its stout habitus and its fore femur and tympanum red and the simple tenth abdominal tergite; but it differs in all the characters described in the previous paragraph. The new species also differs from *T. paraincisa* by the stridulatory file more densely packed with teeth (at the middle with circa 82 teeth per mm instead of 52 teeth per mm).

Etymology. This species is named after Munchie ‘Mun’, the first author’s dog who passed away on 15 November 2024.

Description. Habitus as shown in Figs 19, 20; generally typical for genus and similar to species *Tapiena ?incisa* and *Tapiena dimidia* **sp. nov.** Fastigium in dorsal view narrowly triangular, short, feebly surpassing anterior apex of eyes; furrowed longitudinally, lateral of furrow swollen; sulcus as wide as antennal scapus; with apex roundly truncated (Fig. 21A). Eye prominent, in dorsal view globular slightly protruding anteriorly (Fig. 21A); median and lateral ocelli prominent, round and large (Fig. 21C). Frons very densely and strongly punctuated (Fig. 21C); dorsum of head (Fig. 21A) and genae (Fig. 21B) densely punctuated. Pronotum circa 1.1 times longer than wide, densely punctuated (Figs. 21A). Dorsal disc with anterior margin straight; lateral margins straight and nearly parallel (feebly diverging posteriorly); posterior margin broadly rounded; hind lobe after middle, separated by indistinct and shallow suture; longitudinal furrow barely visible (Fig. 21A). Lateral keel present. Lateral lobe 1.2 times as tall as long; ventral margin fairly long and straight, anterior and posterior margins substraight (Fig. 21B). Thoracic auditory spiracle [= thoracic foramen] covered by pronotal lateral lobe (Fig. 21B). Prosternum unarmed. Mesosternum triangular with subacute apex; metasternum rectangular with anterior angle obtusely rounded, posterior angle 90° and rounded. Tegmen and hind wing fully developed. Hind wing with apex distinctively projecting beyond tegmen; exposed apex with dorsal and ventral margins straight and tapering to subacute apex (Figs 20C, 20D). Legs generally with very short and fine setae. Fore coxa with distinct, long, fairly straight (only slightly curved at base) spine. Fore tibia with external tympanum open, oval; internal tympanum slit covered by large conchate swelling (Fig. 21D). Hind femur with genicular lobe rounded, without any spine.

Male. Tegmen with anterior margin straight and posterior margins convex, distinctly widened in the middle before tapering to narrowly-rounded apex; punctuated with many small transparent cells (Figs 20A, 20B). Tegminal venation: Radius sector (Rs) originating before mid-length, with fork longer than stem (Figs 20A, 20B). Stridulatory file of left tegmen crescent shaped, 2.9 mm in length (Fig. 21E); area around file not swollen; file at anal end with

circa 16 stout teeth, thereafter, teeth very densely and evenly spaced elongated (more closely packed at the sides than in the middle); file at middle with circa 82 teeth per mm and teeth circa 0.11 mm long (Fig. 21E). Mirror on left tegmen made up of network of inter-crossed veins, margins unclear (Fig. 21E). Mirror on right tegmen longer than broad, rectangular but somewhat angularly bent at middle (Fig. 21F).



FIGURE 19. *Tapiena muna* sp. nov. in their natural environment at Sinipung Hill.

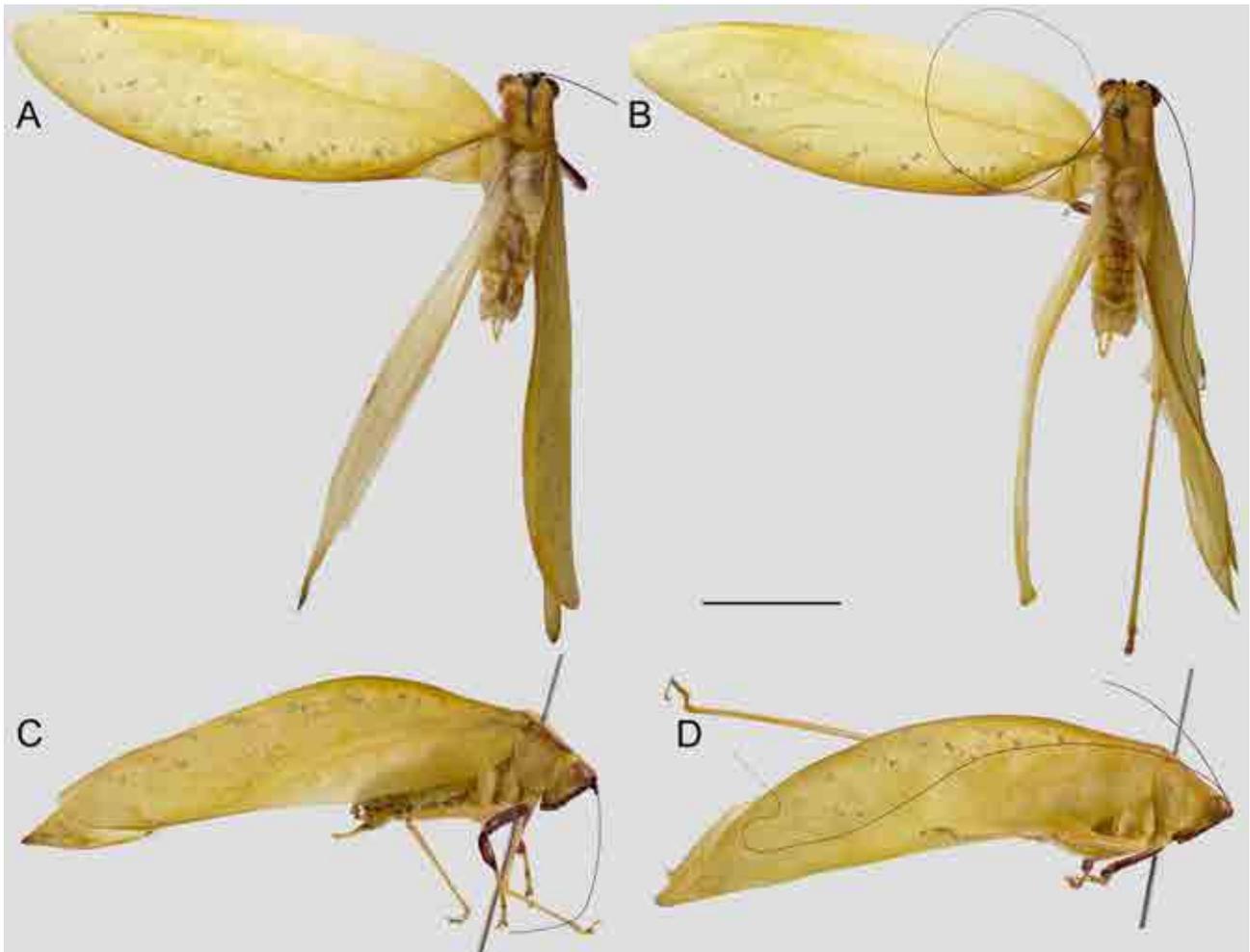


FIGURE 20. Habitus of *Tapiena munae* sp. nov. in dorsal (A, B) and lateral (C, D) views of holotype (A, C) and paratype (B, D). Scale bar: 10 mm.

Tenth abdominal tergite simple, with little or no modification, without tooth or long process apically; at posterior end with two triangular lateral lobes (with rounded apices) and having posterior margin between lateral lobes truncated and roundly excised at middle (Figs 21G–I). Epiproct tongue-shaped, concealed beneath tenth abdominal tergite (Fig. 21I). Cercus stout, bent at middle (instead of arcuated) with its apex having three tooth-like spines; two lateral spines larger than medial one (Figs 21G–I). Subgenital plate broad basally, gently tapering into shaft; with anterior margin concave; with posterior margin deeply excised at middle, laterally extended into two long and narrow lobes; styli slightly longer than apical excision of subgenital plate, tapering into obtuse apex (Fig. 21J).

Female. Unknown.

Colouration. Generally green when alive (Fig. 19), except face red, from fastigium to frons to clypeus and labrum (except median ocellus); scape and pedicel black dorsally, red ventrally; apical segment of maxillary palps and lateral keels of pronotum having tints of red (Figs 21A–C). Fore coxa (apical end), fore femur and anterior half of fore tibia (including tympanum) red with tint of black (Fig. 21D). Abdomen mostly white or pale green when alive (Fig. 19).

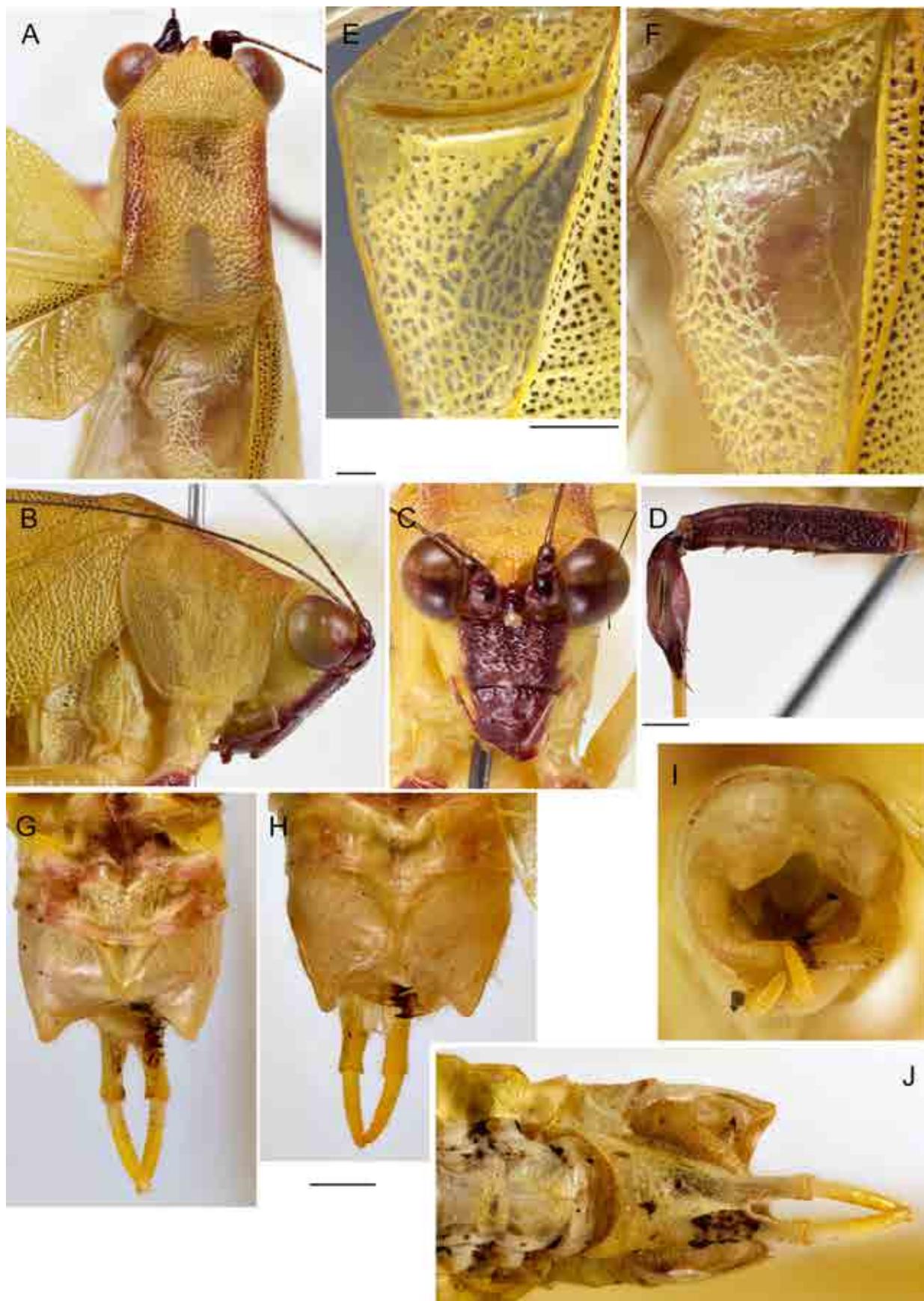


FIGURE 21. *Tapiena muna* sp. nov.: head, pronotum and anterior parts of tegmina in dorsal (A), lateral (B) and anterior (C) views; fore femur and inner tympanum (D); stridulatory area of the left (E) and right (F) tegmina in ventral and dorsal views, respectively; abdominal apex in dorsal (G, H), posterior (I) and ventral (J) views. Scale bars: 1 mm.

Measurements (in mm). See Table 1.

TABLE 1. Measurements (in mm) of *Tapiena dimidia* sp. nov. and *Tapiena muna* sp. nov.

	BL	BWL	PL	PW	TL	TW	HWT	HFL	HFW	HTL
<i>Tapiena dimidia</i> sp. nov.										
Holotype	17.9	39.6	4.2	3.7	31.3	7.1	3.6	14.8	2.7	14.9
Paratype	18.6	40.0	4.6	3.9	33.5	6.1	3.9	16.0	3.0	16.8
<i>Tapiena muna</i> sp. nov.										
Holotype	17.3	42.0	4.1	3.9	36.4	11.2	3.5	-	-	-
Paratype	19.0	42.6	4.6	4.1	35.7	11.1	4.4	-	-	-

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